[11839/33]

RACK-AND-PINION ELECTRO-STEERING SYSTEM

The present invention relates to a rack-and-pinion electro-steering system, particularly for motor vehicles, having a rack extending in a housing, which is operatively connected to a thrust member/pinion pairing.

Rack-and-pinion electro-steering systems are operated by an electrical system instead of a hydraulic system. It is made up of an electric motor, a gear unit for power transmission as well as the control electronics and sensor system. The steering torque exercised by the driver is evaluated by the sensor system of the power steering and is converted into an electrical signal which is converted by the electric motor and the gear unit into a corresponding servo-torque and transmitted to the steering. Known rack-and-pinion electro-steering systems are steering column drives, pinion drives, double pinion drives as well as axially parallel drives.

In the known rack-and-pinion electro-steering systems, the rack is thrust by one or two thrust members against a corresponding number of pinions so as to produce a good tooth-engagement between the pinion and the rack. In general, rack-and-pinion electro-steering systems have two pinions or pinion toothings, one pinion being connected to the servo-side, i.e. to the electric motor and the other pinion being connected to the sensor side or the steering column. For this purpose, the thrust members guide the rack and thrust it against the pinion toothing.

Disadvantageous is the fact that the rack-and-pinion electro-steering system can produce disturbing noises. One source of noise is the rack and another source of noise are the thrust members. The noise generation is especially high in rack-and-

pinion electro-steering systems that have two thrust member/pinion pairings, due to the degrees of freedom at the rack and thrust members. The disturbing noise generation, however, occurs also in rack-and-pinion electro-steering systems that have merely one thrust member/pinion pairing. A cause of the noise generation is to be found in the fact that the different toothing forces on the sensor side and servo-side cause a tilting of the rack which results in a knocking of the steering system particularly in rapidly alternating steering.

In a disadvantageous manner, the tilting of the rack also results in a high degree of wear of the pinion toothing.

Irrespective of, or in addition to, the noise generation on account of the rack, undesired noises are also generated by the fact that the thrust members, which are embedded in a housing part, have a tendency to tilt.

The known thrust members are made from aluminum or generally from metal and have a sliding film at their concave contact surface facing the rack. Generally an O-ring is located between the thrust member and the surrounding housing part, which is to prevent dust from entering.

In this connection, DE 100 49 570 A1 and the following documents must be mentioned as related art: DE 199 29 932 C2, DE 33 32 483 C2, DE 694 12 701 T2, DE 28 07 005 A1 and DE 34 08 673 C2.

The present invention is based on the objective of creating a rack-and-pinion electro-steering system, which solves the above-mentioned disadvantages, preventing in particular the occurrence of disturbing noises in a simple and cost-effective manner and minimizing the wear of the pinion toothing.

According to the present invention, this objective is achieved by the characterizing part of Claim 1.

Due to the fact that between the rack and the housing a bearing is provided for guiding the rack, the thrust members now only have to absorb the toothing forces. Disturbing noises due to a tilting of rack are thereby prevented. Thus knocking is avoided even in rapidly alternating steering.

The bearing between the rack and the housing also minimizes the wear of the pinion toothing in a particularly advantageous manner. In the design approaches known from the related art, the tilting of the rack resulted in a high degree of wear, which is minimized now that the bearing prevents a tilting of the rack.

The use of a bearing between the rack and the housing surrounding the rack is suited in a particularly advantageous manner for rack-and-pinion electro-steering systems having two pinions which engage into the rack when thrust by the respective associated thrust member. For this purpose, one pinion is operatively connected to the servo-side of the electric motor and one pinion is operatively connected to the sensor side or to the steering column. Irrespective of the fact that the design approach according to the present invention is particularly suited for this purpose, in rack-and-pinion electro-steering systems having only one thrust member/pinion pairing, as e.g. in a steering column drive or in a pinion drive, a reduction of the wear in the pinion toothing is achieved as well due to the optimum guidance of the rack.

According to the present invention, the bearing is designed as a sliding bearing. This is because experiments have shown

that a construction of the bearing between the rack and the housing as a sliding bearing is suited particularly well for a reliable, durable and cost-effective guidance of the rack in the housing.

In addition, for mounting the sliding bearings on the rack, a lock geometry is provided by which the sliding bearings may be locked after having been mounted on the rack. The lock geometry for example may be based on the lock geometry customary in sealing rings in automatic transmissions.

Advantageous embodiments of the present invention are derived from the subordinate claims:

Accordingly, two sliding bearings may further be provided for guiding the rack in the housing.

As experiments have likewise shown, guiding the rack in the housing using two sliding bearings also allows for a particularly suitable guidance, which eliminates a tilting of the rack and hence the occurrence of noises and a high wear of the pinion toothing.

A further development of the present invention may additionally provide for the thrust member to be manufactured essentially from plastic, preferably from a slide-modified high-performance plastic.

Due to the fact that the thrust member is essentially made of plastic, noises between the thrust member and the housing part surrounding the thrust member are minimized. It is advantageous for this purpose if the thrust member is manufactured using injection molding technology from a slide-modified high-performance plastic such as Torlon 4301, which

produces the same thermal linear expansion as the housing material used.

Movements of the thrust member generally run radially with respect to the rack and result from knocks or similar effects on the rack which are accordingly transmitted to the thrust member. Due to the refinement made from plastic or in an advantageous manner from a slide-modified plastic, the thrust member can readily move with respect to the housing part without causing disturbing noises. A refinement of the thrust member made from plastic or from a high-performance plastic additionally allows for an elimination of the O-ring hitherto necessary in thrust members made of metal or aluminum, which is supposed to prevent dust, dirt and the like from entering. The possible omission of the O-ring eliminates another source of noise. Due to the minimal contact surface of the O-ring at the housing and its easy deformability, hitherto known thrust members have tended to tilt around the O-ring. In that the O-ring is now eliminated and the thrust member is instead made from plastic, a tilting and the associated noises are prevented.

Moreover, the hitherto required sliding film, which the thrust member has on its concavely formed side facing the rack, may be omitted. This simplifies the handling in the installation of the thrust member since now only a single part needs to be installed. On the other hand, the manufacture of a thrust member from plastic is possible in a simple and cost-effective manner compared to the existing thrust members made of metal or aluminum.

Advantageous refinements and further developments of the present invention are derived from the additional dependent claims and from exemplary embodiment represented in the following with the aid of the drawing.

The sole figure of the drawing shows a rack-and-pinion electro-steering system having a housing, a rack extending in the housing as well as two thrust member/pinion pairings, which are operatively connected with the rack, the rack being guided in the housing by two sliding bearings.

Rack-and-pinion electro-steering systems are sufficiently known from the general related art and are generally used as an alternative to a hydraulic system. Rack-and-pinion electro-steering systems essentially exist as pinion drives, as double pinion drives or as axially parallel drives. Depending on the variant, one or two pinions engage in the rack.

Since rack-and-pinion electro-steering systems are already sufficiently known from the general related art, in the following only the features essential for the present invention will be addressed in more detail.

The rack-and-pinion electro-steering systems according to the present invention, however, is not limited to this.

The exemplary embodiment shows a section of a rack-and-pinion electro-steering system having a housing 1 and a rack 2 extending within it. Rack 2 is here operatively connected with two pinions 3a, 3b, each of which have one thrust member 4a, 4b assigned to it. In a manner not shown, pinion 3a is connected in the exemplary embodiment to a servo-side or an electric motor, while pinion 3b is connected to a sensor side or to a steering column that is likewise not shown.

Between rack 2 and the cylindrical part 1c of housing 1 surrounding rack 2, two bearings in the form of sliding bearings 5 are situated. Sliding bearings 5 are used for

guiding rack 2 in housing 1, which means that this task no longer has to be assumed by thrust members 4a, 4b. Thrust members 4a, 4b therefore only have to absorb the toothing forces. It is advantageous if housing 1, particularly cylindrical housing part 1c, is honed throughout.

The exemplary embodiment provides for a plastic, preferably a high-performance plastic suitable for high temperatures, to be used as the material for manufacturing sliding bearings 5. High-performance plastics such as Solvay Torlon 4301 or DuPont Vespel SP211 are suited for this purpose in a particularly preferred manner. A manufacture of sliding bearings 5 using injection molding technology has proven to be particularly suitable. For mounting sliding bearings 5 on rack 2, a lock geometry is provided in the exemplary embodiment by which sliding bearings 5 may be locked after having been mounted on rack 2. The lock geometry for example may be based on the lock geometry customary in sealing rings in automatic transmissions.

The exemplary embodiment provides for sliding bearings 5 to be situated in each case as closely as possible in the region of pinion 3a or 3b since occurring noises may thus be additionally attenuated in a particularly advantageous manner. Moreover, sliding bearings 5 are thus spaced particularly far apart from each other, which provides for a particularly advantageous guidance of rack 2. If the possibility exists, sliding bearings 5 may also be inserted in cylindrical part 1c of housing 1 as an alternative to the arrangement of sliding bearings 5 on rack 2.

The exemplary embodiment provides for sliding bearings 5 to be situated in a tooth-free region of rack 2 such that a contact with pinions 3a, 3b is precluded.

In order to suppress noise generation in the region of thrust members 4a, 4b, the exemplary embodiment provides for a sliding bearing or a sliding bushing 6 to be used between thrust member 4a, 4b and housing part 1a, 1b surrounding thrust members 4a, 4b, which spans the contact region between the respective thrust member 4a, 4b and the surrounding housing part 1a, 1b. Thus a noise generation through the movement of thrust members 4a, 4b in relation to housing parts 1a, 1b is reduced or eliminated completely.

In the hitherto known design approaches with respect to the related art, thrust member 4a, 4b made of metal or aluminum rubbed against the respective housing parts 1a, 1b, which on the one hand produced noises and on the other hand resulted in a corresponding wear. Merely the use of an O-ring between the respective thrust member 4a, 4b and housing part 1a, 1b, which was to keep out dust and the like, was hitherto provided for. In this connection, the inventors established that the thrust members known from the related art tilt about the O-ring and deform it, which results in the already mentioned noises and signs of wear. These noises are effectively prevented by using a sliding bushing 6 or a sliding bearing. As the exemplary embodiment reveals, sliding bushing 6 assigned to the respective thrust member 4a or 4b extends across the entire width of thrust member 4a or 4b.

Sliding bushing 6 advantageously acts as a sound buffer between the components as well as minimizing friction.

The exemplary embodiment provides for sliding bushing 6 to be essentially made from a plastic, preferably a high-performance plastic. For this purpose, the same high-performance plastic may be used as in the already mentioned sliding bearings 5. A manufacture using injection molding technology is suitable in a particularly advantageous manner for this purpose as well.

The exemplary embodiment shown provides for sliding bushings 6 to be inserted into housing part 1a, 1b.

As an alternative to sliding bearings 5 or sliding bearings 6, the use of known bearings or bearing bushings obvious to one skilled in the art is possible as well.

A variant of the design approach according to the present invention, which is not shown, can provide for thrust members 4a, 4b to be manufactured essentially from plastic, preferably from a high-performance plastic. The high-performance plastic already described with respect to sliding bearings 5 is suitable for this purpose. It is advantageous in this regard if the high-performance plastic is slide-modified as e.g. Torlon 4301. The advantage in this variant, in which thrust members 4a, 4b are essentially made of plastic, is that both the O-ring required in the existing related art as well as the sliding film facing rack 2 may be omitted. The required ability to slide is ensured by thrust member 4a, 4b due to the construction made of plastic. In comparison to the exemplary embodiment, sliding bushing 6 may also be omitted. A construction of thrust members 4a, 4b from plastic makes it possible that now only one single piece needs to be installed.

The design approach according to the present invention is not only suitable for the rack-and-pinion electro-steering systems shown in the exemplary embodiment. Rather, the design approach according to the present invention fits all known rack-and-pinion electro-steering systems. For this purpose, in a simple embodiment, it is also possible to use only one sliding bearing 5 or generally one bearing for guiding the rack in the housing.

Reference numerals

1	housing
1a	housing part (thrust member 4a)
1b	housing part (thrust member 4b)
1c	cylindrical housing part
2	rack
3a	pinion
3b	pinion
4a	thrust member
4b	thrust member
5	bearing, sliding bearing (rack housing)
6	sliding bearing, sliding bushing (thrust member housing part)